

A biodiversity monitoring framework for South Africa: progress and directions

Belinda Reyers^{a*} and Melodie A. McGeoch^b

Global declines in biodiversity, and the associated impacts on human wellbeing, have triggered national and international agreements to reduce or halt these trends. The Convention on Biological Diversity's 2002 commitment, 'to achieve, by 2010, a significant reduction in the current rate of biodiversity loss....', is an often cited example and has caused a flurry of activity in the development of biodiversity monitoring systems. At a national scale, South Africa's National Environmental Management: Biodiversity Act and associated legislation have highlighted the need for a national biodiversity monitoring framework. The National Biodiversity Strategy and Action Plan makes a significant contribution to the development of this framework. As South Africa begins to implement the action plan, a review of existing national monitoring programmes in terms of global and national biodiversity monitoring requirements is important. This paper presents the results of a review of these national programmes, to provide a broad overview, assess alignment with national and global requirements, evaluate gaps and discuss a way forward in the devising of a national biodiversity monitoring framework. We find that the National Biodiversity Strategy and Action Plan aligns well with the Convention on Biological Diversity's 2010 target objectives, but differs in terms of the indicators proposed. Existing national biodiversity monitoring programmes also exhibit these indicator differences and show several gaps in indicator development and data collation. These gaps raise concern around the country's ability to report on the Convention on Biological Diversity's 2010 target, but together with the sound platform provided by the National Biodiversity Strategy and Action Plan, provide a good indication of national priorities and a way forward through a combination of short-term achievable tasks and longer-term development of programmes.

Introduction

South Africa, like other biodiverse regions of the world, is experiencing rapid and extensive rates of biodiversity loss, primarily as a consequence of development-related habitat conversion.¹⁻⁴ Concern over the extent of these global declines in biodiversity, and their effects on human wellbeing,⁵ have triggered national and international agreements to reduce or halt these trends. The 2002 commitment of the Convention on Biological Diversity (CBD), 'to achieve, by 2010, a significant reduction in the current rate of biodiversity loss at the global, regional and national levels',^{7,8} is one such example. The CBD's '2010 target' (hereafter referred to as the 2010 Target) has sparked the creation of national and global biodiversity monitoring systems with which to measure progress towards this and other policy targets.⁹ Monitoring involves the 'intermittent (regular or irregular) series of observations in time, carried out to show the extent of compliance with a formulated standard or degree of deviation from an expected norm'¹⁰ and can be used for basic research, accounting and certification, status assessment and measurement of effectiveness.¹¹

The global interest in biodiversity monitoring is mirrored in South Africa. It is driven by the country's commitments to the

2010 Target, as well as by a spate of new national biodiversity-related policies [for example, the National Environmental Management: Biodiversity Act (NEMBA¹²) and the National Biodiversity Strategy and Action Plan (NBSAP¹³)], all of which highlight the need for a national biodiversity monitoring framework. The policies driving this framework are based on the recognition of South Africa's needs and national research requirements, namely, improved data, knowledge and understanding of biodiversity, its measurement and management, and its links to human wellbeing.

Monitoring is driven by multiple objectives and stakeholders and, as a consequence, requires more than a single approach to satisfy these manifold demands. Indeed, there are many monitoring approaches and indicators currently in use, largely due to the variety of objectives of monitoring programmes, that differ also on spatial and temporal scales.^{11,14-16} The absence of a single universal approach to monitoring biodiversity^{17,18} highlights the need for a formalized strategic approach, as outlined in Fig. 1,^{14,15,19,20} to serve as a framework for all biodiversity monitoring programmes. This ensures that the choice of approach is determined by the purpose and context of these programme (Fig. 1). Importantly, the 2010 Target has highlighted the need for standardized and comparable methods for measuring and monitoring biodiversity status and loss,^{14,21} and has identified a suite of broadly accepted indicators.^{8,21}

In a South African context, the NBSAP,^{13*} which aims to 'conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa, now and in the future', makes significant progress towards the development of a national biodiversity monitoring framework. It represents the outcome of the scoping phase of the creation of a national biodiversity monitoring framework (Fig. 1). Along with the National Spatial Biodiversity Assessment (NSBA^{3,22}), it forms the basis for the national biodiversity framework, which is, in part, South Africa's response to its obligations under the CBD.¹³

Although the interest in biodiversity monitoring has recently intensified, South Africa has a history of environmental and biodiversity assessment; for instance, the National State of the Environment Report²³ and the National Environmental Indicators Programme.²⁴ As South Africa moves towards implementing NBSAP and the required national biodiversity monitoring framework, it is useful to review these existing programmes in relation to national and global biodiversity monitoring requirements. This will help ensure alignment, identify gaps and priorities, and develop an effective and efficient final framework. The main objectives of this paper are thus to: provide a broad over-

*Abbreviations

Acronym	Definition
BIOTA	Biodiversity Monitoring Transect Analysis
CBD	Convention on Biological Diversity
GMO	Genetically modified organism
HI	Headline indicator
IAS	Invasive alien species
IPCC	Intergovernmental Panel on Climate Change
NBSAP	National Biodiversity Strategy and Action Plan
NEIP	National Environmental Indicators Programme
NEMBA	National Environmental Management: Biodiversity Act
NSBA	National Spatial Biodiversity Assessment
NSoER	National State of the Environment Report
OAI	Outcomes, activities and indicators
SARGSPC	South Africa's Response to the Global Strategy for Plant Conservation
SAEON	South African Environmental Observation Network

^aNatural Resources and the Environment, CSIR, P.O. Box 320, Stellenbosch 7599, South Africa.

^bCentre for Invasion Biology, Department of Conservation Ecology and Entomology, University of Stellenbosch, Private Bag X1, Stellenbosch 7602, South Africa.

*Author for correspondence. E-mail: breyers@csir.co.za

view of current national biodiversity monitoring and assessment efforts, assess their alignment with the 2010 Target, evaluate remaining gaps, and discuss the way forward in the process of developing a national biodiversity monitoring framework for South Africa.

This will be done through a review of: (i) the focal areas and headline indicators (HIs) of the 2010 Target⁸; (ii) the outcomes, activities and indicators (OAI) of NBSAP¹³; (iii) the indicators, used and monitored in the National State of the Environment Report (NSoER²³); (iv) the indicators and monitoring programmes proposed by the National Environmental Indicators Programme (NEIP) of the Department of Environmental Affairs and Tourism²⁴; (v) the indicators used by the National Spatial Biodiversity Assessment³; and (vi) the targets set by South Africa's Response to the Global Strategy for Plant Conservation (SARGSPC²⁵).

NSoER²³ was South Africa's first national assessment of the state of the environment. It was followed by NEIP²⁴, which aimed to develop a set of core indicators for environmental reporting, a key gap identified by NSoER. NSBA^{3,22} was the country's first comprehensive spatial assessment of biodiversity aimed at informing the policies, plans and activities of a wide variety of sectors, by pointing to broad priority areas for future conservation action. SARGSPC²⁵ provides a status report on the implementation of the Global Strategy for Plant Conservation in South Africa, focusing on target achievement and challenges facing the country.

The Biodiversity Monitoring Transect Analysis (BIOTA) AFRICA and the South African Environmental Observation Network (SAEON) are additional examples of monitoring programmes in South Africa. The BIOTA AFRICA network is an integrated, interdisciplinary, multinational approach to the study of change in biodiversity on the African continent as a consequence of altered land use and climate in West Africa, East Africa, and southern Africa (www.biota-africa.org). The BIOTA Southern Africa project concentrates on research in Namibia and South Africa. In South Africa, it includes four BIOTA observatories at which long-term monitoring activities are planned and have been initiated. SAEON is a research facility, which serves as a platform for long-term studies of ecosystems and aims to advance understanding of environmental change detection, prediction and management through environmental observatories, field stations or sites linked by an information management network (www.saeon.ac.za). These two programmes and other sub-national biodiversity monitoring projects were not included in this review.

Table 1 reflects the results of the review, where the 2010 Target framework (column A), the NBSAP framework (column B) and the existing indicator and monitoring programmes (column C) are aligned. The strength of this alignment is also recorded within the table. Based on this assessment, we discuss the NBSAP alignment with the 2010 Target, followed by a discussion of the current national programme alignments and conclude with proposals for a way forward.

National Biodiversity Strategy and Action Plan, and the 2010 Target

The CBD recognizes that national participation towards meeting the 2010 Target must be informed and driven by national priorities.²⁶ Nonetheless, the efficiency and effectiveness of meeting both national and global targets may be maximized by identifying where the alignment of national and 2010 Target goals and indicators is strongest. This will expedite short-term biodiversity assessment and reporting by focusing on the development and monitoring of those indicators meeting multiple objectives. In addition, identifying where national and global objectives differ also provides interesting insight into the relative importance of biodiversity status, threats and sustainable-use priorities across local to global scales.

In the case of the NBSAP¹³ strategic objectives and the 2010 Target, the latter has short-term objectives (albeit potential

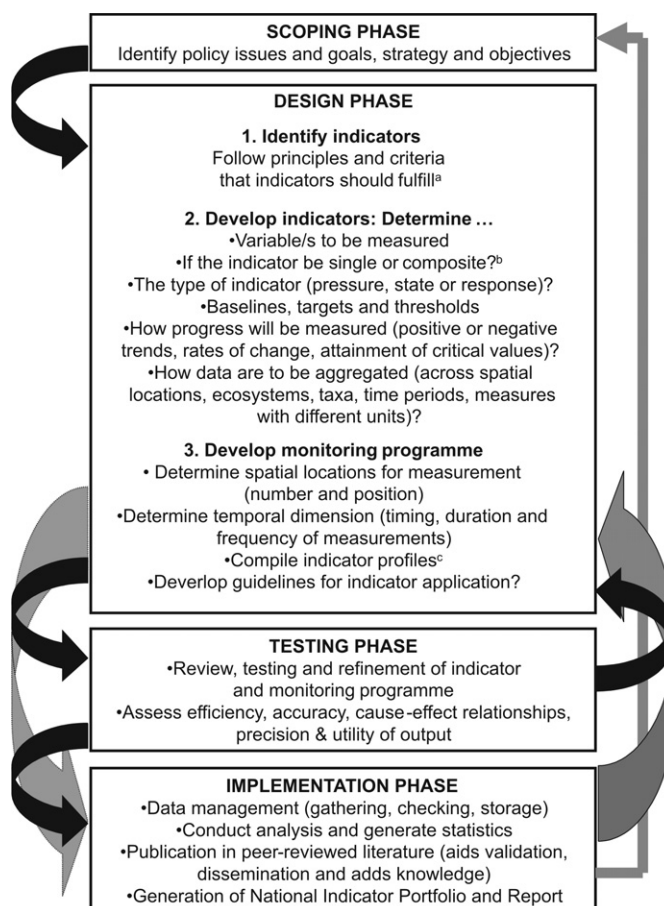


Fig. 1. Process for the development, testing and implementation of biodiversity indicators in assessment and monitoring (adapted from refs 14, 15). ^aRefs 15, 26; ^brefs 15, 37; ^cindicator profiles outline exact units, calculation procedures, baseline values, current values and cause-and-effect relationships that aid unambiguous interpretation of trends.¹⁵

long-term benefits), whereas NBSAP provides a long-term national strategy, albeit with short (5-year) and intermediate (15-year) targets, and provision for updating NBSAP every five years. Nonetheless, the 2010 Target provides impetus to national strategies to achieve some objectives in the short term. NBSAP's strategic objectives and the 2010 Target focal areas are strongly aligned, with the focus on conservation of all levels of biodiversity and ecological processes, minimizing threats to biodiversity, sustainable use and the maintenance of ecosystem services (Table 1).

Mechanisms for meeting the above strategic objectives are identified in the form of 22 HIs in the 2010 Target, and as several OAI in the NBSAP.¹³ There is strong alignment between NBSAP and five of the HIs, moderate alignment with nine HIs, and weak alignment on the remaining 8 HIs (Table 1). Areas of strongest procedural alignment (via indicators to be quantified) include HIs of: (i) protected areas, (ii) threatened species, (iii) the broad-scale extent of ecosystems, (iv) alien invasive species and (v) water quality (Table 1). The most poorly aligned areas from the procedural perspective include HIs of: (i) trends in non-threatened, non-rare and non-utilized species (which have been shown to be of great value in monitoring programmes²⁷⁻²⁹), (ii) the trophic integrity of terrestrial ecosystems, (ii) incidence of ecosystem failure and (iv) habitat connectivity and fragmentation. Other weakly aligned HIs are those addressing socio-cultural (rather than biodiversity) sectors in South Africa, such as linguistic diversity, the wellbeing of ecosystem service-dependent communities, and the status of resource transfer. Nonetheless, biodiversity information to support and inform both biodiversity and socio-cultural policy are a strong theme in NBSAP.

For example, the action plan includes the quantification and monitoring of the value of biodiversity to the economy and to people's lives (Outcome 1.1). While overarching policy goals have strong commonalities, the processes by which these goals are to be achieved differ moderately. This reflects interesting differences between South African and global priorities, as well as characteristics peculiar to South Africa's constitutional imperatives, that is, a strong focus on equity, benefit sharing and traditional knowledge that are in the main addressed by other, non-biodiversity-related, institutional frameworks.

There are two areas where the NBSAP has a clear set of objectives that do not form an explicit part of the 2010 Target HIs, namely, the threats to biodiversity from climate change and from genetically modified organisms. The former is largely dealt with outside the CBD and its global targets by, for example, the Intergovernmental Panel on Climate Change. The latter reflects South Africa's distinctive position of currently having a high GM biotechnology adoption rate and under-developed policy, and virtually no ecological research in this area.^{30,31} By contrast, the strong alignment in the area of invasive alien species is a consequence of South Africa's identification of the control and management of invasive alien species (IAS) as a national priority in 1995, and the implementation of significant IAS management and research programmes.²⁵

Monitoring (along with quantification, assessment, evaluation and research) is stated as an explicit part of five of the 27 outcomes of the five strategic objectives of the NBSAP. Nonetheless, if progress towards and success in meeting all these objectives are to be evaluated, then monitoring must necessarily form an integral part of all of the plan's activities (as recognized in Activity 2.3.4¹³). The link between the CBD and the NBSAP is formalized as one of the plan's 15-year targets under Strategic Objective 1: that 'South Africa fully and consistently meets international obligations regarding biodiversity in the context of national priorities'.

Current national indicator and monitoring programmes

A review of the existing national monitoring frameworks and programmes in terms of the NBSAP and 2010 Target monitoring requirements will assist in the identification of current needs and set a future course for biodiversity monitoring in South Africa. Many of these programmes were established before the advent of the CBD and NBSAP targets, yet could provide essential information or even be modified to align with these new developments. They form an essential component of the creation of a national biodiversity monitoring framework. There are three stages during the design phase of biodiversity indicator development, as shown in Fig. 1. These include the identification of indicators, further development of each indicator, followed by the drawing up of a monitoring programme, in which data will be collected with the use of each indicator. We have used these same stages to assess progress in this review (Table 1: C). This overview concentrates on only those NBSAP outcomes that align with the 2010 Target HIs.

The alignment between 2010 Target focal areas and identified indicators from national frameworks is strong for HIs associated with biodiversity status, trends and threats, and for water ecosystem services. Alignment is moderate for HIs of genetic diversity and sustainable use, and weak for the rest (Table 1: C1). These trends also reflect the priorities and sectoral foci in existing and proposed monitoring programmes which informed the NBSAP. Although SARGSPC has not identified indicators, and is only in the goal-setting phase (Fig. 1), it makes an important contribution to the development of a national biodiversity monitoring framework by addressing key gaps in the NEIP around indicators of sustainable use, genetic diversity and indigenous knowledge (but limited to plant conservation). The absence of these indicators from NEIP is perhaps a reflection of the history of biodiversity monitoring in South Africa, where these issues have only recently begun to receive attention from the bio-

diversity sector (e.g. sustainable use and genetic diversity) or fall within the mandate of other sectors (e.g. ecosystem services and indigenous knowledge).

Assessing the alignment of indicators which have already been developed (NSoER, NSBA, Table 1: C2) and for which data have been collated, reveals more gaps. While some alignment exists for indicators of biodiversity status, trends and threats, very few indicators have been developed for the focal areas of sustainable use, ecosystem integrity and services. Almost no indicators have been identified or devised for the socio-cultural themes of indigenous knowledge, access and benefit sharing and resource transfers. These gaps are potentially a result of both the historical sectoral focus mentioned above, but are also strongly influenced by data availability and the resources required to collect new data. This is demonstrated by the comparatively good data and indicator development at a national scale on ecosystems and selected species distributions, compared to the general absence of data and developed indicators at the sub-specific level, for example, population trends, and genetic diversity. Another information need that becomes apparent is the establishment of thresholds (see Fig. 1), especially those for sustainable use and management. Regardless of the purpose, monitoring presumes the existence of information on a 'norm' or 'standard' against which levels and directions of change may be assessed.^{20,26} Without this baseline information, indicators of sustainability cannot be evaluated. In terms of indicators of ecosystem integrity and services, water quantity and quality have received most of the attention. This reflects the country's prioritization of water resources and the excellent data collation by the national water management sector over many years.

National gaps in the current monitoring (Table 1: C3) of these indicators are apparent in Table 1. Although many indicators have been proposed in the NEIP (Table 1: C4), very few have actually been developed and implemented. This gap raises concerns over South Africa's ability to report on many of the 2010 Target HIs, which are largely trend-based and thus require repeated assessment and reporting through monitoring programmes. Some of the proposed indicators and monitoring programmes may have trend data available in 2010, but immediate action is required to develop these biodiversity assessment and monitoring programmes to meet this deadline.

Priorities for the development of a national biodiversity monitoring framework

The NBSAP provides a sound starting point for the development of a national biodiversity monitoring framework, which aligns well with South Africa's international 2010 Target reporting commitments. However, Table 1 makes it clear that there is much work to be done in converting this alignment into an implemented national biodiversity monitoring framework. Indeed, it would appear from Table 1 that South Africa will not be able to report on most of the HIs or OAs by 2010 without paying urgent attention to the creation and implementation of the framework. Framework development includes relatively easy tasks like the collation of existing data for established indicators (for instance, the status of threatened species, and trends in the abundance of some species) or the reassessment of existing indicators (for example, NSBA ecosystem status) to generate trend information. It also includes the tasks of identifying and devising indicators and collecting data for HIs or OAs where they do not exist (e.g. measures of genetic diversity, population trends, sustainable use, and indigenous knowledge).

It is important to recall that Table 1 does not reflect the totality of monitoring requirements for South Africa's biodiversity and indicates only those elements of interest to the 2010 Target. The development of a national biodiversity monitoring framework should focus on issues beyond 2010 identified by the NBSAP as important to the country. Table 1 and the resultant national priorities do, however, provide a good place to start this rather daunting task.

Table 1. Alignment of the South African National Biodiversity Strategy and Action Plan (NBSAP) with the Convention on Biological Diversity's 2010 Target and with existing and proposed national monitoring frameworks.

A. 2010 Target framework		B. NBSAP framework		C. Indicator and monitoring development in South Africa*			
Focal areas (bold) and headline indicators (HIs)	Relationship to 2010 Target HIs	Primary OAI sections relevant to 2010 HIs		C1: Identified	C2: Developed	C3: Monitored to date	C4: Proposed monitoring
Status and trends of the components of biodiversity							
1. Trends in the extent of selected biomes, ecosystems, and habitats	Good relationship demonstrated in NSBA, trends available after reassessment in 2010.	A: 1.4.2, 2.5.4 IO: 1.4	NEIP		NSBA: Ecosystem status	No	NSBA: 5-yearly
2. Trends in abundance and distribution of selected species	Little focus here at present, emphasis on threatened species. Selected species unknown.	IO: 4.4	NEIP		NSBA: Broad-scale distribution	No	NEIP: Annually/5-yearly, species dependent
3. Coverage of protected areas	Strong relationship in NSBA, trends available after reassessment in 2010. 15-year targets of comprehensive monitoring, target coverage of 12% terrestrial & 20% marine (exceeds Target 1.1 of 2010 Framework).	SO: 5 O: 5.2, 5.5 A: 2.5.6, 5.2.1, 5.2.3 IO: 5.2	NEIP		NSoER, NSBA: Protection levels	No	NSBA & NEIP: 5-yearly
4. Change in status of threatened species	Five-year target, thus by 2010, Uses population trends of selected species of special concern in support of biodiversity management, and an improvement in the status of threatened species (Target 2.2 of 2010 Framework).	O: 5.4 A: 2.5.4, 5.4.1 IO: 2.5, 5.2, 5.4	NEIP SARGSPC target: No indicator identified		NSoER number of threatened species per taxa	NSoER: For plants 1980–1995	NEIP: 5-yearly
5. Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socioeconomic importance	Conservation of genetic diversity is a 5-year target to achieve the sustainable use of biological resources. The percentage of genetic diversity of priority species conserved would be quantified by 2010, with reassessments providing trend data.	O: 4.1 A: 1.4.1, 3.2.4 IO: 4.1	SARGSPC target: No indicator identified		No	No	No
Sustainable use							
6. Area of forest, agricultural and aquaculture ecosystems under sustainable management	Outcomes related to this HI via sustainability of extractive use of biological resources. Related activities include integration of biodiversity considerations into forestry and selected agricultural sectors, and into production lands in priority biodiversity areas. The related indicator is the percentage of productive lands managed consistent with conservation of biodiversity (Target 4.1 of 2010 Framework).	O: 4.3, 4.4 A: 3.2.1, 3.2.2, 5.3.4, 4.4.1–4.4.5 Related to IO: 3.2	SARGSPC target: No indicator identified		No	No	No
7. Proportion of products derived from sustainable sources	Relevant activities include encouragement of sustainable fishing practices, the identification of, and research on, sustainable use of priority resources. The indicator and data of this 5-year target should be available by 2010.	A: 3.2.4, 4.3.1 IO: 4.4	NEIP (marine fisheries), SARGSPC targets: No indicator identified		NSoER: Fisheries catches	NSoER: Fisheries catches 1938–1997	NEIP: Annual
8. Ecological footprint and related concepts	The per capita 'geological' footprint is an indicator of the 5-year target to demonstrate that SA's natural capital is not declining. Data in support of this HI should be available by 2010.	IO: 1.1	No		No	No	No
Threats to biodiversity							
9. Nitrogen deposition	Nitrogen deposition per se not targeted, although pollution in general is.	SO: 3, 0 3.1, 3.6 A: 2.5.5, 3.6.1	NEIP: Variety of measures		NSoER: Fertilizer usage, pollution indicators	NSoER: Fertilizer, 40 years	NEIP: Variable
10. Trends in invasive alien species	Fifteen year target includes effective control of priority species, and several 5-year targets reinforce this objective. Data are thus highly likely to be available to feed into this HI by 2010 albeit not sufficient temporal repeats to establish trends until approximately 2015	SO: 3, 0: 3.3, A: 2.5.5, 2.6.3, 3.3.1–3.3.4 IO: 3.3	NEIP: Number, abundance and distribution of species		NSoER 1999: Aquatic species distribution; NSBA: Potential distribution of plant species	No	NEIP: 5-yearly
Ecosystem integrity and ecosystem goods and services							
11. Marine Trophic Index (MTI)	Although many marine biodiversity indicators are proposed, the mean trophic level of fisheries landings (to form the MTI) is not explicitly mentioned.	A: 1.4.2, 3.1.5, 3.1.6	NEIP: Catch measures but not explicitly trophic levels		No	No	No

A. 2010 Target framework		B. NBSAP framework		C. Indicator and monitoring development in South Africa*			
Focal areas (bold) and headline indicators (HIs)	Primary OAI sections relevant to 2010 HIs	Relationship to 2010 Target HIs	C1: Identified	C2: Developed	C3: Monitored to date	C4: Proposed monitoring	
12. Water quality of freshwater ecosystems	A: 1.4.2, 2.5.4, 3.1.3, 3.1.4 IO: 3.1	15-year target includes effective management of catchments, and activities directly address assessment and management of freshwater ecosystems. Indicators include estuarine health, river system habitat integrity, pollution management.	NEIP: Several measures of surface and ground water quality.	NSBA: Main river ecosystem status; NSoER: Several measures of water quality.	NSoER: Several decades of data	NEIP: Annually	
13. Trophic integrity of other ecosystems		Not directly considered in NBSAP (2005).	No	No	No	No	
14. Connectivity/fragmentation of ecosystems	IO: 3.2	Little focus currently, although index of fragmentation per unit area for priority vegetation types is an indicator with a 5-year target to achieve the integration of biodiversity into key production sectors.	Not explicitly	NSBA: Fragmentation maps	No	NSBA: 5-yearly	
15. Incidence of human-induced ecosystem failure		Not directly considered in NBSAP (2005).	No	No	No	No	
16. Health and wellbeing of communities who depend directly on local ecosystem goods and services	A: 2.3.8	Direct quantification of this HI receives little focus at present. Several outcomes, activities and targets are aimed at ensuring sustainable and equitable sharing of services.	NEIP: Several proposed indicators.	No	No	NEIP: 5-yearly	
17. Biodiversity for food and medicine	A: 1.4.1	Addressed indirectly by setting quantitative biodiversity targets to assess the status of all useful species.	NEIP: Economic contribution of species & trends in indicator species.	No	No	NEIP: Variable	
Status of traditional knowledge, innovations and practices							
18. Status and trends of linguistic diversity and numbers of speakers of indigenous languages		Not considered in NBSAP (2005).	No	No	No	No	
19. Other indicator of the status of indigenous and traditional knowledge	Target under O: 4.1 A: 1.2.2, 4.1.3	This includes encouragement of beneficiation of indigenous knowledge and maintenance of indigenous knowledge with respect to genetic diversity and valuable species.	SARGSPC target: No indicator identified.	No	No	No	
Status of access and benefits sharing							
20. Indicator of access and benefit-sharing	SO: 4, O: 4.1, 4.2 A: 4.1.1–4.1.4 IO: 4.1	Benefit-sharing agreements, material transfer agreements and bioprospecting regulations are set as indicators, with five-year targets, for ensuring access and benefit sharing.	No	No	No	No	
Status of resource transfers							
21. Official development assistance provided in support of the Convention		Not considered in NBSAP (2005).	NEIP: Conservation budgets	NSoER: DEAT budget and donor programmes	No	NEIP: Annual	
22. Indicator of technology transfer		Not considered in NBSAP (2005).	No	No	No	No	

*SO, Strategic objective; O, outcome; A, activity; IO, indicator of outcome (jointly referred to as OAI).

*NEIP, National Environmental Indicator Programme;²⁴ NSoER, National State of the Environment Report;²⁵ NSBA, National Spatial Biodiversity Assessment;²⁶ SARGSPC, South Africa's Response to Global Strategy for Plant Conservation.²⁸ Shading: dark grey = good alignment with 2010 Target and NBSAP monitoring requirements, light grey = moderate alignment, no shading = weak alignment.

South Africa's position at the beginning of the process of developing a biodiversity monitoring framework is not unique; indeed, the creation of the NBSAP and NSBA makes it more advanced than most countries. In addition, several of the 2010 Target HIs are themselves still in the development phase.³² While some of these headline indicators are well-established, globally recognized and have a history of assessment and application [such as the Living Planet Index³³ and the status of threatened species (IUCN Red List of Threatened Species³⁴)], others have received comparatively little attention, and have not been fully developed or broadly adopted.³²

It is thus clear that, in taking on this challenge, not only are scientific expertise and capacity fundamental,^{6,14} but, as emphasized by de Heer *et al.*,³⁵ Dobson *et al.*¹⁶ and Gregory *et al.*,³⁶ the results of the creation, testing and implementation of indicators and monitoring programmes should be published in peer-reviewed scientific journals to establish both their credibility and widespread acceptance.

Conclusion

By focusing on the easy to achieve tasks, South Africa will be able to meet some of its reporting commitments for the 2010 Target and the NBSAP's 5-year targets. Furthermore, an urgent synthesis of existing knowledge and scattered data sets will highlight key gaps in our knowledge.¹⁶ This focus should not, however, come at the expense of the more challenging tasks. Biodiversity monitoring remains essential beyond 2010, as highlighted by the longer-term NBSAP objectives and plans to renew the NBSAP in the future. By including long-term challenges and considering future gaps during the development of a national biodiversity monitoring framework, we can move beyond the generally reactive nature of biodiversity monitoring. We also need to reach beyond the continued reliance on existing data, which has resulted in the biases in data availability and understanding that we see today, by investing in biodiversity data collection. The success of this current design phase in creating a national biodiversity monitoring framework, as well as its implementation, is thus critical to stemming the loss of biodiversity in South Africa.

We thank SAEON for the opportunity to prepare this review, and the CSIR and Centre for Invasion Biology, University of Stellenbosch, for funding. Jessica Conradie and others at the South African National Biodiversity Institute are thanked for their contributions, as well as two reviewers.

- Mittermeier R.A., Hoffmann M., Pilgrim J.D., Brooks T.B., Mittermeier C.G., Lamoreux J.L. and Fonseca G. (eds) (2005). *Hotspots Revisited: Earth's biologically richest and most endangered ecoregions*. Cemex, Mexico City.
- Reyers B., Fairbanks D.H.K., van Jaarsveld A.S. and Thompson M. (2001). Priority areas for the conservation of South African vegetation: a coarse filter approach. *Divers. Distrib.* 7, 77–96.
- Driver A., Maze K., Rouget M., Lombard A.T., Nel J., Turpie J.K., Cowling R.M., Desmet P., Goodman P., Harris J., Jonas Z., Reyers B., Sink K. and Strauss T. (2005). *National Spatial Biodiversity Assessment 2004: Priorities for Biodiversity Conservation in South Africa*. Strelitzia 17. South African National Biodiversity Institute, Pretoria.
- Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, D.C.
- Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington, DC.
- Pereira H.M., and Cooper H.D. (2006). Towards the global monitoring of biodiversity change. *Trends Ecol. Evol.* 21, 123–129.
- UNEP (2003). Consideration of the results of the meeting on '2010–The Global Biodiversity Challenge'. UNEP/CBD/SBSTTA/9/inf/9. Online: www.biodiv.org/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-09-en.pdf
- UNEP (2003). Proposed biodiversity indicators relevant to the 2010 target. UNEP/CBD/SBSTTA/9/INF/26. Online: www.biodiv.org/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-26-en.pdf
- Balmford A., Crane P., Dobson A., Green R.E. and Mace G.M. (2005). The 2010 challenge: data availability, information needs, and extraterrestrial insights. *Phil. Trans. R. Soc. B* 360, 221–228.
- Hellawell J.M. (1991). Development of a rationale for monitoring. In *Monitoring for Conservation and Ecology*, ed. F.B. Goldsmith, pp. 1–14. Chapman and Hall, New York.
- Stem C., Margoluis R., Salafsky N. and Brown M. (2005). Monitoring and evaluation in conservation: A review of trends and approaches. *Conserv. Biol.* 19, 295–309.
- The National Environmental Management: Biodiversity Act*, No. 10 of 2004. Department of Environmental Affairs and Tourism, Pretoria (2004).
- South Africa's National Biodiversity Strategy and Action Plan*. Department of Environmental Affairs and Tourism, Pretoria (2005).
- The Royal Society (2003). *Measuring Biodiversity for Conservation*. Royal Society, London.
- McGeoch M.A. (in press). Insects and bioindication: theory and progress. In *Insect Conservation Biology*, eds A.J.A. Stewart, O.T. Lewis, and T.R. New. CABI, London.
- Dobson A. (2005). Monitoring global rates of biodiversity change: challenges that arise in meeting the Convention on Biological Diversity (CBD) 2010 goals. *Phil. Trans. R. Soc. B* 360, 229–241.
- Biggs R., Scholes R.J., ten Brink B.J.E. and Vačkář D. (in press). Biodiversity indicators. In *Assessment of Sustainability Indicators*. Island Press & SCOPE, Washington, DC.
- Noss R.F. (1990). Indicators for monitoring biodiversity: a hierarchical approach. *Conserv. Biol.* 4(4), 355–364.
- UNEP (2003). Monitoring and indicators: Designing national-level monitoring programmes and indicators. UNEP/CBD/SBSTTA/9/10. Online: www.biodiv.org/doc/meetings/sbstta/sbstta-09/official/sbstta-09-10-en.pdf
- McGeoch M.A. (2002). Bioindicators. In *Encyclopedia of Environmental Metrics*, eds A.H. El-Shaarawi, and W.W. Piegorsch, pp. 186–189. John Wiley, Chichester.
- UNEP (2004). Provisional global indicators for assessing progress towards the 2010 biodiversity target. UNEP/CBD/COP/7/INF/33. Online: www.biodiv.org/doc/meetings/cop/cop-07/information/cop-07-inf-33-en.pdf
- Reyers B., Rouget M., Jonas Z., Cowling R.M., Driver A., Maze K. and Desmet P. (2007). Developing products for conservation decision-making: lessons from a spatial biodiversity assessment for South Africa. *Divers. Distrib.* 13, 608–619.
- National State of the Environment Report*. Department of Environmental Affairs and Tourism, Pretoria (1999).
- Environmental Indicators for National State of the Environment Reporting South Africa 2002*. Department of Environmental Affairs and Tourism, Pretoria (2002).
- Willis C.K. (ed.) (2006). *Conserving South Africa's Plants: a South African response to the Global Strategy for Plant Conservation*. SANBI Biodiversity Series 1. South African National Biodiversity Institute, Pretoria.
- UNEP (2003). Report of the expert meeting on indicators of biological diversity including indicators for rapid assessment of inland water ecosystems. UNEP/CBD/SBSTTA/9/INF/7. Online: www.biodiv.org/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-07-en.pdf
- Leon-Cortes J.L., Cowley M.J.R. and Thomas C.D. (1999). Detecting decline in a formerly widespread species: how common is the common blue butterfly *Polyommatus icarus*? *Ecography* 22, 643–650.
- Siriwardena G.M., Baillie S.R., Crick H.Q.P. and Wilson J.D. (2000). The importance of variation in the breeding performance of seed-eating birds in determining their population trends on farmland. *J. Appl. Ecol.* 37, 128–148.
- Green D.M. (2003). The ecology of extinction: population fluctuation and decline in amphibians. *Biol. Conserv.* 111, 331–343.
- McGeoch M.A. and Pringle K.L. (2005). Science and advocacy: the GM debate in South Africa. *S. Afr. J. Sci.* 101, 7–9.
- McGeoch M.A. and Rhodes J.I. (2006). Ecological risk assessment of genetically modified organisms in South Africa: An assessment of the current policy framework. *CIB Occasional Paper No. 2*, Centre for Invasion Biology, Stellenbosch University, Stellenbosch. Online: www.sun.ac.za/cib/occasion.htm
- Mace G., Delbaere M.B., Hanski I., Harrison J.A., Novo E.G., Pereira H.M., Watt A.D. and Weiner J. (2005). *A User's Guide to Biodiversity Indicators*. European Academy of Sciences Advisory Council. Online: www.easac.org/EASACBio-indicator.pdf
- Loh J., Green R.E., Ricketts T., Lamoreux J., Jenkins M., Kapos V. and Randers J. (2005). The Living Planet Index: using species population time series to track trends in biodiversity. *Phil. Trans. R. Soc.* 360, 289–295.
- Butchart S.H.M., Stattersfield A.J., Baillie J., Bennun L.A., Stuart S.N., Akcakaya H.R., Hilton-Taylor C. and Mace G.M. (2005). Using Red List Indices to measure progress towards the 2010 target and beyond. *Phil. Trans. R. Soc.* 360, 255–268.
- De Heer M., Kapos M. and Ten Brink B.J.E. (2005). Biodiversity trends in Europe: development and testing of a species trend indicator for evaluating progress towards the 2010 target. *Phil. Trans. R. Soc.* 360, 297–308.
- Gregory R.D., Van Strien A., Vorisek P., Gmelig Meyling A.W., Noble D.G., Foppen R.P.B. and Gibbons D.W. (2005). Developing indicators for European birds. *Phil. Trans. R. Soc.* 360, 269–288.
- Buckland S.T., Magurran A.E., Green R.E. and Fewster R.M. (2005). Monitoring change in biodiversity through composite indices. *Phil. Trans. R. Soc.* 360, 243–254.